Project Assignment for the Course

Internet Software Architectures

Computer and Control Engineering / Information Engineering

Generation 2023/2024

1. System Purpose

The project assignment requires the implementation of a web application that serves as a centralized information system for companies involved in the procurement of medical equipment. Through this system, private hospitals will be able to reserve and collect equipment. Administrators also have access to the system and can enter reports on equipment sales. The system manages a large number of companies registered within the information system. The primary purpose of the application is to maintain records of employees, registered companies, equipment reservations, pick-up schedules, users, and their profiles.

2. User Types

The system distinguishes the following user types:

- **Registered User:** An employee of a private hospital who can reserve an equipment pick-up time, cancel a reservation at least 24 hours before the scheduled time, view scheduled pick-up appointments, and submit complaints. Each registered user has a profile where their order history is recorded. Users do not have access to the profiles of other system users.
- **Company Administrator:** Has access to client profiles who have reserved equipment and their pick-up history. The company administrator can view a graphical representation of all scheduled appointments. Each administrator can only be employed by one company.
- **System Administrator:** r Registers new system administrators, company administrators, and companies. The system administrator is responsible for addressing complaints from registered users and defining the loyalty program.
- **Unauthenticated Users:** Can browse companies, register on the system, and log in if already registered.

3. Functional Requirements

3.1. Display of Information for Unauthenticated Users

Unauthenticated users have access to the registration and login pages of the system. They can browse companies and available equipment, but they are not allowed to make reservations and do not have their own profile. They do not have access to other data within the system. For successful implementation, it is necessary to ensure security both on the server side and the client side.

3.2. User Registration and Login

On the registration/login page, users can log in using their email address and password. If a user is not yet registered in the system but wishes to access the benefits available to registered users, they must first register on the appropriate page. The registration process includes entering the email address, password, first name, last name, city, country, phone number, occupation, and company information. The password is entered in two fields to prevent errors during the selection of a new password. After completing the required information, an activation link will be sent to the provided email address. The user cannot log in to the application until their account is activated by visiting the link they received in the email.

Note: It is **essential** to implement a mechanism for user authentication and authorization on the server side. **Authorization must be implemented for all functionalities, regardless of how tasks are divided among the students!**

3.3. User Profile

A registered user can update their personal information on their profile page. Changing the email address is not allowed. On their profile, the user can:

- view their penalty points
- see the user category they belong to and the benefits they have (related to the loyalty program).

3.4. Company Administrator Profile

The company administrator can edit the company profile, which includes:

- company name,
- address (with location displayed using maps),
- description,
- average company rating,
- available times for equipment pickup,
- list of other company administrators.

The company administrator has the ability to define available times for equipment pickup, which registered users can book with a single click.

For each available time slot, the following details must be defined:

- first and last name of the company administrator who will hand over the equipment,
- Date, time, and duration of the appointment

The company administrator can also:

- search for, add, modify, and remove equipment offered by the company (if a pickup time has been created for equipment and the user has not yet picked it up, the equipment cannot be deleted),
- track the delivery of equipment to private hospitals in real-time,
- update their personal details,
- change their password,
- upon first login, they must change their password.

Note: A company can have multiple administrators, but each administrator can only manage one company.

3.5. System Administrator Profile

System administrators can:

- register companies and their administrators,
- respond to user complaints,
- define the loyalty program,
- add other administrators (there is one predefined system administrator),
- upon first login, they must change their password.

3.6. Company Profile

The company profile page must display the following information:

- company name and address (with an additional map view of the address),
- a list of equipment available in stock,
- a list of all available equipment pick-up slots,
- the average rating of the company.

From the company profile page, a registered user should be able to:

Schedule an equipment pick-up appointment

3.7. Home Page for Authenticated Users

On the main page for authenticated users, the following links should be available:

- list of companies in the system – Companies can be sorted by name, city, rating, etc.
- pick-up history – Can be sorted by date, price, duration, etc.
- view scheduled pick-up slots for equipment not yet picked up – Cancellations are allowed up to 24 hours before the start.,
- list of all QR code confirmations for scheduled appointments – Filtering by status is possible (new, processed, rejected),
- view penalties – If the user accumulates 3 penalties, they cannot make a new reservation. Penalties are reset on the first day of each month
- complaint page – Allows users to file complaints,
- user profile – For managing personal details.

Note: Only the pages listed above need to be accessible from the user's profile. The organization and design of these pages are left to the students.

3.8. Home Page for Company Administrator

On the main page for the company administrator, the following links should be available:

- list of all registered users who have reserved equipment in this company
- page for entering information about equipment pick-ups
- work calendar,
- page for scheduling new appointments
- company administrator profile.

Note: Only the pages listed above need to be accessible from the administrator’s profile. The organization and design of these pages are left to the students.

3.9. Procedure for Creating Predefined Equipment Pickup Appointments – Company Administrator

Each company has working hours. The company administrator defines the equipment pickup appointments. For each appointment, the following details must be specified date and time of the appointment, duration of the appointment, name and surname of the person who will hand over the equipment (company administrator). These predefined appointments will be visible in the company's work calendar. The company's work calendar is accessible to all employees in the company who can use the application (i.e., administrators).

3.10. Procedure for Scheduling a Predefined Pickup Appointment – Registered User

Step 1: On the company's page, the user searches for and selects the equipment they wish to pick up.
Step 2: Once the equipment selection is complete, a list of predefined pickup appointments is displayed to the user. The user selects one of these appointments to finalize the reservation.
Step 3: After finalizing the reservation, a confirmation email is sent to the registered user, which includes a QR code containing the reservation details. The appointment is then added to the list of upcoming appointments, accessible through the user's profile.

3.11. Procedure for Scheduling an Emergency Pickup Appointment in the Company – Registered User

Step 1: On the company's page, the user searches for and selects the equipment they wish to pick up.
Step 2: Once the equipment selection is complete, a list of predefined pickup appointments is displayed to the user. If none of the predefined appointments suit the user, they can select the option to schedule an emergency pickup appointment.
Step 3: The user selects the date when they wish to pick up the equipment. Based on the selected date, available pickup times are displayed. The user can choose any available appointment time, as long as it falls within the company's working hours.

Step 4: After scheduling the appointment, a confirmation email is sent to the registered user, which includes a QR code containing the reservation details. The appointment is then added to the list of upcoming appointments, accessible through the user's profile. The appointment is also added to the company's working calendar (administrator's calendar), and one of the available company administrators is assigned to the appointment.

3.12. Procedure for Cancelling a Pickup Appointment – Registered User

A registered user can cancel an appointment from their list of upcoming scheduled appointments. If they cancel the appointment, they will receive one penalty point. If the reservation is canceled less than 24 hours before the scheduled appointment time, the user will receive two penalty points. After the appointment is canceled, it should be made available for other registered users to attempt to schedule. A registered user can only schedule one appointment at the same time with the same company.

3.13. Procedure for Equipment Pickup – Company Administrator

On the equipment pickup page, the company administrator should have the ability to select a reservation that has not yet been picked up. If the reservation is still valid, the administrator marks the equipment as successfully picked up by the user. If the pickup deadline has passed, the system automatically cancels the reservation, and the user receives 2 penalty points. After the user picks up the reserved equipment, a confirmation is sent to their email, and the quantity of equipment in the system is reduced. Only the administrator is allowed to issue the equipment to the user.

3.14. Procedure for equipment pickup via QR code – Company Administrator

The equipment pickup process is implemented by uploading a QR code. The QR code contains a list of equipment that has been reserved and needs to be handed over to the user, along with the reservation number.

If the reservation is still valid, the company administrator marks the equipment as successfully picked up by the user. If the pickup deadline has passed, the system automatically cancels the reservation, and the user receives 2 penalty points.

After the reserved equipment is picked up, a confirmation is sent to the user's email, and the quantity of the equipment in the system is reduced. Only the administrator is authorized to issue the equipment to the user.

3.15. Search and Filtering of Companies

On the page that displays the list of companies, there is an option to enter the company name or location. For each search result, the company name, address, and its rating are displayed. Search results can be filtered based on various criteria, such as rating, distance, etc. The page for searching and filtering companies is accessible to unauthenticated users, registered users, and system administrators.

3.16. Search and Filtering of Equipment

On the page displaying the list of equipment, there is an option to enter the name of the equipment that needs to be ordered. For each search result, the equipment name, type, and description are shown. It is also necessary to display a list of companies where the equipment is available. The search results can be filtered based on various criteria, such as rating, equipment type, etc. The page for searching and filtering equipment is accessible to registered users, company administrators (only for their own company), and system administrators.

3.17. Graphical Display of the Company’s Work Calendar - Company Administrator

The company administrator, on their profile, has the option to view the company’s work calendar at a weekly, monthly, and yearly level. For each day of the month, all the scheduled appointments should be displayed, including the start time, duration, and the name of the user who made the reservation.

3.18. Complaint Submission and Response Procedure

A user can file a complaint for a company (only if they have made at least one reservation with the company) and a company administrator (only if they have made at least one reservation with that specific company administrator).
The text of the complaint is entered in free form. The system administrator can view all complaints and is able to respond to them. The response is written in free form and is sent to the user's email. The user should be able to view the history of the complaints they have submitted, as well as the responses to those complaints.

3.19. Loyalty Program Definition Procedure

The system administrator can define a loyalty program for all users within the entire information system. Additionally, the administrator defines the number of points that a user earns after each successful equipment pickup. Apart from the number of points, the system administrator also defines a scale based on which the user’s category is determined (e.g., Regular, Silver, Gold). When defining the scale, penalties must also be taken into account, as they influence the user's category. Based on the category, the user receives discounts on future purchases.

3.20. Evaluation Procedure

A user can provide a rating for a company, but only if they have made at least one equipment reservation with that company. The user can rate the company only once, but they can change their rating later. Along with the rating, the user can select one or more reasons for their rating, and they can also provide a custom reason in the form of free text.

3.21. Report Creation Procedure

The application allows the company administrator to view business analytics for:

- the average rating of the company.,
- a graphical representation of appointments on a monthly, quarterly, and yearly basis,
- a graphical representation of medical equipment reservations on a monthly, quarterly, and yearly basis,
- the company's revenue for a specified time period.

4. Simulator for Equipment Delivery to Private Hospitals

Private hospitals can subscribe to monthly deliveries of specific equipment. It is necessary to implement an application that simulates the delivery of equipment to a private hospital. From the hospital simulation application, it is possible to create a contract that defines the type of equipment, quantity, and delivery date. At any given time, only one contract can be active between the private hospital and the main system. When a new contract is created or an existing one is modified, the previous contract becomes invalid. The agreed quantities are delivered on the specified day of the month. If it is not possible to deliver the agreed quantity of equipment, a notification is sent to the private hospital a few days in advance.

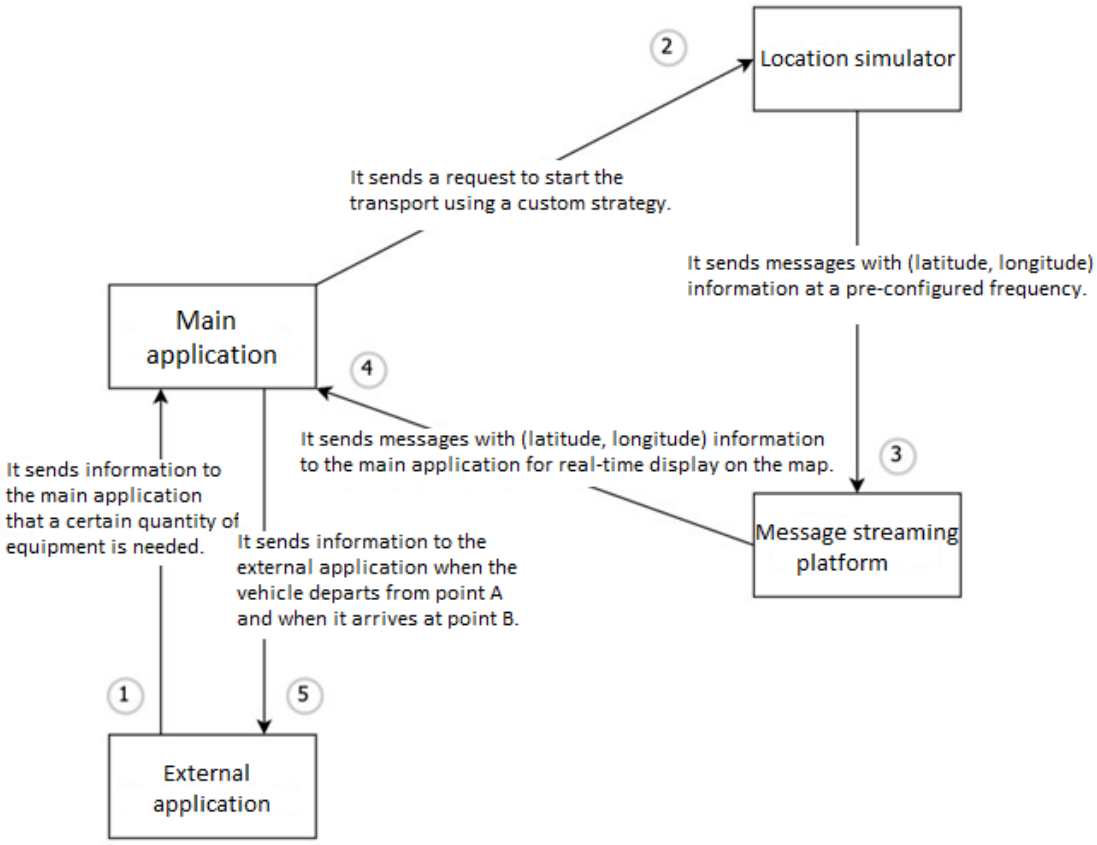
Note: Communication between applications should be implemented asynchronously via message queues. The message formats and communication protocols are left for the students to choose.

5. Location Simulator

It is necessary to implement an application that will simulate the movement of a vehicle for equipment delivery in almost "real-time." The application should generate the coordinates of the vehicle's path from point A to point B and send them for asynchronous processing to a platform (such as Kafka, RabbitMQ, ActiveMQ, etc.), which will further forward these coordinates to the main system of the company for the distribution of medical equipment. The main system will display this information on a map or a vehicle tracking page.

The frequency of sending coordinates (the vehicle's position on the road) should be configurable (e.g., every second, every 3 seconds, 30 seconds, 1 minute, etc.).

An example of the communication flow is shown in the diagram:



Note: The location simulation application can be either console-based or web-based. The communication flow may differ from the one proposed, subject to the assistants' approval.

6. Non-functional requirements

6.1. Server platforms

For the implementation of the project, any server platform can be chosen. Some of the platforms that may be used include:

- Java + Spring Boot
- Java + Play framework
- Java + Spark framework
- NodeJS + Express
- Python + Django
- Ruby on Rails
- .NET

6.2. Client platforms

For the implementation of the project, any client platform can be chosen::

- Classic web application
- Single-page interface application (e.g., Angular + REST services)
- Mobile application (Android or iOS)

The visual appearance of the application affects grades of 7 or higher. A more aesthetically pleasing design certainly leaves a better impression.

6.3. Sending Emails

A special service for sending emails is not provided. You can use your own email account for this purpose. Optionally, you can handle sending notifications via email using a message queue.

6.4. API Design

The API of the main application should be designed and documented according to the OpenAPI specification.

6.5. Concurrent Access to Database Resources

When implementing the system, the following conflict situations must be properly resolved:

- multiple simultaneous users should not be able to reserve equipment that has become unavailable in the meantime.
- the quantity of equipment in stock must be correctly updated after a user has picked up the equipment,
- multiple simultaneous users should not be able to reserve a pickup time that has already become unavailable,
- one company administrator cannot be present at more than one pickup time simultaneously,
- predefined times must not be reserved by multiple users,
- a company administrator cannot define a time that overlaps with a time already reserved by a user,
- multiple company administrators cannot define times that overlap,
- only one system administrator can respond to a single complaint.

Note: It is considered that the student has not successfully fulfilled this requirement if, in addition to the listed constraints, they do not identify and adequately resolve at least one additional conflicting situation for their part of the functionality as prescribed by the specification..

Additionally, each student must upload a PDF for their part of the functionality, which should contain the following:

● description of the conflict situations that were resolved,

● flow diagrams of all client requests and server responses that lead to the detection of a conflict situation in the concrete example of the application the team implemented (it is necessary to indicate which endpoint is targeted in each request and which method of which class),

● description of how the identified situations were resolved (which approach is used, why this approach was chosen, how it was implemented in the code, how the conflict situation was tested).

6.6. Location services

For displaying locations, services such as OpenLayers, Leaflet, Google Maps, Yandex Maps, etc., can be used.

6.7. Graphic display of charts and work calendars

Third-party libraries for drawing elements can be used for the graphic display of work calendars and creating various charts.

6.8. Scalability

It is necessary to prepare a proposal on how the application being implemented in this course will function when the number of concurrent users exceeds the capabilities of a single server. At least two proposals must be implemented on a micro example in the project for the purpose of demonstration, discussion, and defense (caching, partitioning, replication, software load balancer, monitoring, etc.). Assumptions:

- the total number of application users is 100 million,
- the number of reservations for all entities on a monthly basis is 500,000,
- the system must be scalable and highly available.

It is necessary to define a Proof of Concept (PoC) architecture and upload it in PDF format to the project's GitHub repository by the project submission date, which will be announced later.

The document should contain:

1. Database design schema (conceptual, logical, or physical),
2. Proposal for the data partitioning strategy,
3. Proposal for the database replication strategy and ensuring fault tolerance,
4. Proposal for the data caching strategy,
5. Estimated hardware resources required to store all data for the next 5 years,
6. Proposal for setting up a load balancer,
7. Proposal on which user operations should be monitored to improve the system,
8. Complete diagram of the proposed architecture design (application servers, database servers, caching servers, etc.).

Note: The PDF should not contain definitions of what a database, cache, replication, server, and other tools proposed as part of the solution are, but rather the reasons why you chose a specific software, algorithm, hardware, architecture, and what problem their use is solving.

7. Task Distribution

Student 1:

- 3.1, 3.2, 3.10, 3.12, **3.18**, **5**

Student 2:

- 3.3, 3.7, 3.11, 3.15, **3.20, 4**

Student 3:

- 3.4, 3.6, 3.8, 3.9, 3.13, **3.21, 4**

Student 4:

- 3.5, 3.14, 3.16, 3.17, **3.19, 5**

Below are the mandatory items that must be implemented for each grade.

Note: Each higher grade requires the implementation of all the previous requirements covered by lower grades!

- **all grades** – Git must be used for version control, and the repository must be available on GitHub for review by the instructors during the project development and defense. Also, it is necessary to provide clear instructions on how to run the project in the README.md and attach a script for populating the database with test data.
  Note: GitHub commits will be monitored for continuous work. Projects uploaded to GitHub with only a few commits will not be subject to evaluation.
- **6** – All functionalities specified in the requirements must be implemented except those listed for grade 7.
- **7** – All requirements for grade 6, plus requirements 3.18, 3.19, 3.20, 3.21.
- **8 -** All requirements for grade 7, plus requirements 6.4. and 6.5 for all four students.
- **9** – All requirements for grade 8, plus requirement number 4 and requirement number 5.
- **10** – All requirements for grade 9, plus requirement 6.8.

8. Checkpoints

For the first checkpoint, the minimum requirements are to create a model of the entire system and a script for populating the database with data that will be used to demonstrate functionality. Additionally, the following functionalities must be fully implemented:

- Student 1 - Requirement 3.1 and 3.2 (registration only, without login to the system)
- Student 2 - Requirement 3.3 and 3.15
- Student 3 - Requirement 3.4 (updating company data and updating personal data) and 3.6 (without the list of pickup dates)
- Student 4 - Requirement 3.5 (creating the company and company administrators) and 3.16

Students who successfully demonstrate the implemented functionalities are exempt from implementing requirements 3.18, 3.19, 3.20, and 3.21.

For the second checkpoint, it is necessary to previously implement the requested functionalities for the first checkpoint. Additionally, the following functionalities must be fully implemented:

- Student 1 - Requirement 3.2, Requirement 3.10
- Student 2 - Requirement 3.11
- Student 3 - Requirement 3.4 and Requirement 3.9
- Student 4 - Requirement 3.5 to completion (without the loyalty program), Requirement 3.17

Students who successfully demonstrate the implemented functionalities are exempt from implementing Requirement 6.4, the additional conflict situation from Requirement 6.5, as well as creating the PDF document.